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(Article begins on next page)

**Phenology of Adult Stoneflies (Plecoptera) of the Curone Stream  
(Northern Apennines, Italy)**

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## ABSTRACT

We studied the flight periods of 16 stonefly species from Curone stream (northern Apennines, Italy) and grouped them into four categories according to their flight periods - autumnal (*Protonemura salfii* and *Leuctra major*), autumnal-winter (*Leuctra fusca* and *Leuctra hexacantha*), winter-spring (*Leuctra hippopus* and *Leuctra subalpina*), and spring (*Besdolus ravizzarum*, *Isoperla grammatica*, *Perla grandis*, *Perla marginata*, *Brachyptera risi*, *Amphinemura sulcicollis*, *Protonemura intricata*, *Nemoura hesperiae*, *Capnioneura nemuroides* and *Leuctra handlirschi*; probably *D. cephalotes* can also be added to this category, although no adults were observed). Among the adults, *L. fusca* was the most abundant species, while *C. nemuroides* was the rarest. There was partial temporal segregation in the flight periods. In general, the male flight period, at least in some species, occurred slightly in advance to the female flight period.

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## INTRODUCTION

Despite its short duration compared with the longer nymphal stage, the adult stage in stoneflies (Plecoptera) and some other aquatic insects is very important for the dispersion and re-colonization of the upper part of streams in compensation for nymphal drift (Hutchinson 1981, Brittain 1990, Tierno de Figueroa, Luzón-Ortega and Sánchez-Ortega 2003, Fenoglio et al. 2004). Thus, the study of adult phenology of these insects is fundamental to increase the knowledge of this important period of their life cycle.

Moreover, phenological studies acquire special interest nowadays because they can be used as a first signal of the global change effects. This is possible, because water temperature and photoperiod are the main factors regulating the emergence of aquatic insects, and Plecoptera in particular, in temperate areas (Corbet 1964, Hynes 1976, Sweeney 1984, Fenoglio et al. 2005 and 2008). Thus, the aim of the present work is to describe the flight periods of the Plecoptera species inhabiting a northern Apennine stream.

## METHODS AND MATERIALS

The study was made in the Curone Stream (northwest Italy), near Fabbbrica Curone (44° 47' 14'' N, 9° 04' 02'' E, 320 m a.s.l.). At the sampling station, the stream was a typical mountain Apennine lotic environment, with a 4.0-4.5 m width, coarse substrate, and riparian vegetation comprised *Salix* spp., *Populus* spp., and *Robinia pseudoacacia*. Riparian herbaceous vegetation comprised mainly *Conium maculatum*, *Epilobium hirsutum* and Asteraceae. This system shows a good environmental quality, reaching the First Class in the Italian Extended Biotic Index (Ghetti 1997), corresponding to an environment without trace of human-induced alteration.

Adults were collected with an entomological net by sweeping the riparian vegetation and by directly picking individuals from the stones, through a transect of approximately five meters along both sides of the stream. At the sampling site, adults were collected on 17 dates from 13 April 2007 to 25 March 2008. On only one sampling occasion (27 July) were no adults collected. On 1 January 2008, a very small number of individuals was collected probably as a consequence of a stream flood.

The thermal regime of the site was assessed using a temperature datalogger, which recorded temperature every six hours through the year. Water temperature varied considerably during the study period, with a mean of 9.43 °C, a minimum of 0.004 °C in December, and a maximum of 22.3 °C in July (Fig. 1).

## RESULTS AND DISCUSSION

A total of 1,979 adult individuals was collected. Six families (among the European families, only Chloroperlidae was not present) and 16 species were recorded (Table 1). Nymphs of another species of Perlidae (*Dinocras cephalotes*) were collected in the stream, but not adults were captured during the sampling period. Nevertheless, we know from isolated collections made in prior years in this stream that this species presents a spring flight period pattern.

It was very apparent that the spring flight period species predominated, while exclusively summer and winter species were absent. A minor peak occurred in autumn. Nevertheless, while in summer no species were detected, some species (e.g., *Leuctra hexacantha*, *Leuctra fusca*, *Leuctra subalpina*, and *Leuctra hippopus*) showed flight periods extending into winter. In our study area, summer seemed to be the poorest period, as reported in other regions of low Apenninic and non-Apenninic areas (Ravizza and Ravizza Dematteis 1979, Nicolai and Fochetti 1983) and contrasted with what happens at high altitude, where delay in the flight periods of the spring species and advances of the autumnal ones cause a higher number of species flying in summer, as demonstrated also in other areas from southern Europe (e. g., Tierno de Figueroa et al. 2001). Probably, lotic systems of low altitude in the Apennines experience some environmental changes in summer, such as intermittent flow and warmer temperatures, which make oviposition impossible, as pointed out by Nicolai and Fochetti (1983).

When comparing the flight periods of the studied species in this area with their known adult phenology in Italy (Consiglio 1980, Fochetti and Tierno de Figueroa 2008), they are generally within the typical temporal range, although some spring species (e.g., *Besdolus ravizzarum*, *Amphinemura sulcicollis*, and *Protonemura intricata*) begin to fly one or two months earlier, and some typically autumnal species (e.g., *L. fusca* and *L. hexacantha*) showed an extended autumnal-winter flight period in our study area. These data can be explained by the relatively low flow and relatively high temperature of Curone Stream.

When comparing our results with those from another Apenninic stream, the Erro Stream (Ravizza 1976), we observed that the flight periods of spring species were nearly a month delayed in Curone Stream. On the other hand, when compared to Nure Stream (Ravizza and Ravizza Dematteis 1979), no consistent patterns were apparent,

with some species presenting advanced flight periods and others with delayed ones. This could be a consequence of the different environmental characteristics (probably mainly thermal) and demonstrates why data on flight periods should be extrapolated only with extreme caution from certain areas to others.

As previously pointed out by others (e.g., Ravizza and Ravizza Dematteis 1979) in similar areas, the species showing longer flight periods are the autumnal ones. This is the case for *L. fusca*, and *L. hexacantha* in our study stream. *L. fusca* was the most abundant species that we found, which has been similarly noted for other low Apenninic areas (e.g., Ravizza and Ravizza Dematteis 1979, Nicolai and Fochetti 1983). Despite its abundance in the nymphal stage, *D. cephalotes* was not collected as an adult. There was a partial temporal segregation in the flight periods, especially if the large numbers of individuals among the species of the genus *Leuctra* are considered (Fig. 2), and this probably tends to diminish interspecific competition during the nymphal stage and may act as a barrier to mistaken identities of mates between closely related species (Illies 1952). Nevertheless, behavioral cues are used to ensure the correct mating encounters - cues such as the existence of aggregation sites and the employment of vibrational communication (Stewart 1994). This temporal segregation in adults of the *Leuctra* genus as been previously recorded in other areas (Tierno de Figueroa et al. 2002). Our data also show that, in general, the male flight period, at least in some species, occurs slightly in advance of the female one.

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Table 1. Adults of stonefly species collected near Curone Stream, northern Appenines, Italy during the period from 13 April 2007 to 25 March 2008.

Family	Species	Date	Number collected		Temporal flight period group
			Females	Males	
Perlodidae					
	<i>Besdolus ravizzarum</i>	30 April	2	2	Spring
		10 May	3	3	
		17 May	3		
	<i>Isoperla grammatica</i>	10 May	4	5	Spring
		17 May	3	4	
		14 June	1		
		21 June	1	1	
Perlidae					
	<i>Perla grandis</i>	10 May	8	9	Spring
		17 May	1		
	<i>Perla marginata</i>	10 May	1	2	Spring
		17 May	1	12	
		14 June	9	32	
		21 June	6	13	
Taeniopterygidae					
	<i>Brachyptera risi</i>	18 April	2	1	Spring
		30 April	1		
		10 May	2	2	
		25 March		1	
Nemouridae					
	<i>Amphinemuria sulcicollis</i>	13 April	2	1	Spring
		30 April	1		
		10 May	2	2	
		25 March		1	
	<i>Protonemura intricata</i>	30 April		1	Spring
		17 May		2	
	<i>Protonemura salfii</i>	10 October	4		Autumn
	<i>Nemoura hesperiae</i>	13 April	4	7	Spring
		18 April	4	4	
		30 April	2		
		10 May	1		
		17 May	2		
Capniidae					
	<i>Capnioneura nemuroides</i>	13 April	1		Spring

Leuctridae				
<i>Leuctra fusca</i>	5 September	6	2	Autumn-winter
	12 October	218	212	
	20 October	229	214	
	19 November	30	42	
	12 December	12	2	
	21 January	5	3	
	8 February	3		
<i>Leuctra handlirschi</i>	13 April	2	2	Spring
	18 April	1	1	
	30 April	1	2	
	10 May	5	6	
	17 May	39	24	
	25 March	6	10	
<i>Leuctra hexacantha</i>	5 September	11	21	Autumn-winter
	12 October	69	12	
	20 October	9	3	
	19 November	2	1	
	12 December	1		
	21 January	1		
<i>Leuctra hippopus</i>	13 April	5	2	Winter-spring
	18 April	2		
	8 February	1		
	11 March	99	144	
	25 March	41	49	
<i>Leuctra major</i>	12 October	8	2	Autumn
<i>Leuctra subalpina</i>	30 April	3		Winter-spring

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### **Caption to Figures**

Figure 1. Water temperature variation during the study period.

Figure 2. Seasonal succession in the flight period of the six *Leuctra* species collected in the Curone Stream.

Fig. 1

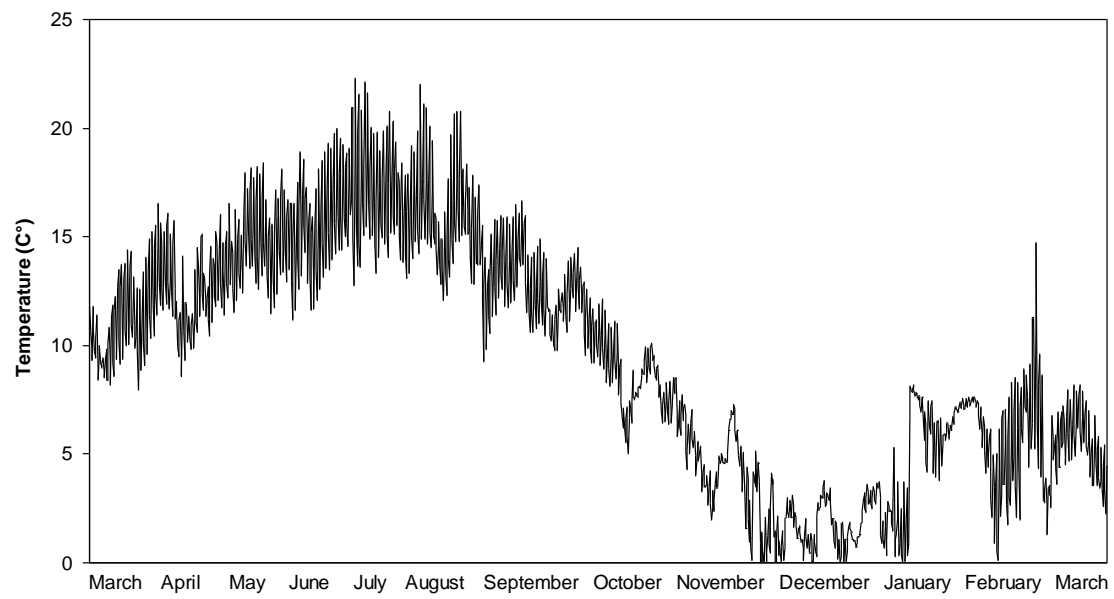


Fig. 2

